enough to act as predators). In the absence of evidence from other sources, it seems most likely that the ocellus functions as a component of Batesian mimicry rather than as a deflective target, but it may also startle a predator.

On the basis of field and aquarium observations, it is apparent that, when threatened, most reef-fish prey species take shelter in the reef and await the eventual departure of the predator. What then would be the selective advantage to a prey species to pose in a vulnerable location rather than to flee and hide? The strategy of the mimic appears to be one of intimidation. Rather than flee into the refuge of the reef when it encounters a predator, *Calloplesiops* simulates the abundant and aggresive moray, frightening away a predator and thereby reducing the time spent by *Calloplesiops* in less productive activities.

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References and Notes

1. W. Wickler, *Mimicry in Plants and Animals* (McGraw-Hill, New York, 1968); J. Randall and H. Randall, *Bull. Mar. Sci. Gulf Caribb.* **10**, 444 (1960); J. Randall and A. Emery, *Zoologica* **56**, 115 (1971).
2. Aquarium observations are based on six specimens, presumably collected in the Philippines, of *Calloplesiops* that have been in captivity since December 1973. I made field observations along the western coast of Grande Comore Island, Indian Ocean, during February and March 1975.
3. *Calloplesiops altivelis* (Steindachner) was described as *Plesiops altivelis* and includes *Barrosia barrosi* Smith in its synonymy.
4. E. Hobson, *Fish. Bull.* **72**, 915 (1974).
5. R. Hiatt and D. Strasburg, *Ecol. Monogr.* **30**, 65 (1960).
6. C. Rettenmeyer, *Annu. Rev. Entomol.* **15**, 43 (1970).
7. The necessity and importance of certain of the listed characters, particularly items (iii) and (iv), is debatable.
8. Müllerian mimicry is based on the premises that (i) two or more species are unpalatable, (ii) if two or more species are indistinguishable by predators, they will be captured in proportion to their abundance, and items (iv) to (vi) of the Batesian mimicry criteria (*6*).
9. Because of the scarcity of *Calloplesiops*, the simple but conclusive experiment of feeding a series of *Calloplesiops* to various predators was not attempted.
10. J. E. Randall, K. Aida, T. Hibiya, N. Mitsuura, H. Kamiya, and Y. Hashimoto [*Publ. Seto Mar. Biol. Lab.* **19**, 157 (1971)] outlined the procedure for identifying the presence of skin toxins and discovered them to be present throughout the family Grammistidae. Ichthyologists consider the Grammistidae and Plesiopidae to be related families within the suborder Percoidei [see, for example, P. H. Greenwood, D. E. Rosen, S. Weitzman, G. S. Myers, *Bull. Am. Mus. Nat. Hist.* **131**, 341 (1966)].
11. E. Poulton, *The Colours of Animals* (International Scientific Series, LXVIII, London, 1890); H. Cott, *Adaptive Coloration in Animals* (Meuthen, London, 1940).
12. A. Blest, *Behaviour* **11**, 209 (1957).
13. Six specimens from Steinhart Aquarium and preserved specimens from the fish collections of the California Academy of Sciences, National Museum of Natural History, and J. L. B. Smith Institute of Ichthyology.
14. A. Blest, *Zoologica* **49**, 161 (1964).
15. Comoran fieldwork supported by a grant from the C. H. Breeden Foundation. I thank R. MacPherson for insight, P. Ehrlich and G. Barlow for advice, and T. McHugh/Photo Researchers and D. Powell for photographs.

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The Development of Language-Like Communication Without a Language Model

Abstract. *Deaf children who are unable to acquire oral language naturally and who are not exposed to a standard manual language can spontaneously develop a structured sign system that has many of the properties of natural spoken language. This communication system appears to be largely the invention of the child himself rather than of the caretakers.*

Must a child experience language in order to learn language? Clearly some experience with language is necessary for the child to learn the established language of his particular community. The child of English-speaking parents learns English and not Hopi, while the child of Hopi-speaking parents learns Hopi, not English. But what if a child is exposed to no conventional language at all? Surely such a child, lacking a specific model to imitate, could not learn the conventional language of his culture. But might he elaborate a structured, albeit idiosyncratic, language nevertheless?

We have observed a group of children who lack specific linquistic input but who otherwise have normal home environments. Our subjects are deaf children of normal intelligence whose hearing losses prevent them from acquiring oral language naturally in the home. These children's hearing parents have decided against exposing them to a manual sign language in order to concentrate on oral education (*1*). At the point at which we studied these subjects, their oral education program had not produced significant learning; they had acquired few, if any, spoken-language items that they could use regularly in their daily activities.

Six deaf children of hearing parents (two girls and four boys), ranging in age from 17 to 49 months at the first interview, were visited in their homes by two experimenters for 1 to 2 hours at intervals of approximately 6 to 8 weeks. The experimenters provided a standard set of toys for the child to play with during the interview and videotaped the informal interaction of mother, experimenter, child, and toys. Each videotaped session was coded by one of the experimenters or a research assistant. Selected samples were coded by both experimenters in order to calculate reliability scores on the coding categories.

The videotaped sessions were used to develop a coding system (*2*). (i) Instances of communicative gestures were designated in the stream of motor behavior (*3*). In a randomly selected sample of videotape, 82 percent of the gestures identified by either of two coders were identified and similarly described by both coders. (ii) On the basis of physical criteria, these gestures were broken down into single units analogous to words or signs and into multisign units analogous to phrases (*4*). Of the gestures identified by both coders, there was 95 percent agreement on sign boundary assignment and 85 percent agreement on phrase boundary assignment. (iii) By the method of "rich interpretation" (*5*), referential designates (such as Santa Claus or twist) were assigned to all word signs, and semantic elements, cases, and predicates (such as agent or act) (*6*) were assigned to the individual signs in all multisign phrases. Of the gestures identified by both coders, there was 98 percent agreement on reference assignment and 96 percent agreement on semantic element assignment.

Using these descriptive categories, we found that each of our deaf subjects developed a structured communication system that incorporates properties found in all child languages (*7*). They developed a lexicon of signs to refer to objects, people, and actions, and they combined signs into phrases that express semantic relations in an ordered way.

Lexicon. The children developed two types of signs to refer to objects and actions (*8*). First, they used deictic signs, typically pointing gestures which, like proforms in English (such as "this" or "there"), effectively allow the child to make reference to any object or person in the present. However, as is the case with proforms, context is necessary to interpret these signs. During the study, David, Donald, Dennis, Chris, Kathy, and Tracy produced, respectively, 4854, 1806, 309, 401, 1218, and 366 deictic signs, representing 52, 62, 49, 41, 52, and 52 percent of the signs each child produced.

The children produced a second type of sign, characterizing signs, which are motor-iconic signs that specify actions,

Table 1. Comparison of number of characterizing signs produced during sessions 1 to 4 by mothers and children. *Types* refers to number of different characterizing signs; *tokens* refers to number of occurrences across types.

Subject	Types			Tokens			
	Child	Mother	In common	Child	Mother	In semantic relation phrases	
						Child	Mother
David	56	54	18	107	90	47	9
Dennis	25	23	5	50	58	18	3

objects, and, less frequently, attributes. The form of a characterizing sign is related to its referent by apparent physical similarity. For example, a closed fist bobbed in and out near the mouth referred to a banana or to the act of eating a banana. Two hands flapped up and down at shoulder height referred to a bird or the act of flying. As a result of this motor-iconicity, the characterizing sign is less dependent on context for interpretation than is the deictic sign. David, Donald, Dennis, Chris, Kathy, and Tracy each produced, respectively, 210, 76, 25, 59, 35, and 95 different types of characterizing signs throughout the study.

Syntax and semantics. In addition to these lexical accomplishments, the children concatenated their deictic and characterizing signs into multisign phrases that conveyed relations between objects and actions. For example, one child pointed at a shoe and then pointed at a table to request that the shoe (patient) be put on the table (recipient). On another occasion, the child pointed at a jar and then produced a twisting motion in the air to comment on mother's having twisted open (act) the jar (patient). Another child opened his hand with his palm facing upward and then followed this "give" sign with a point toward his chest, to request that an object be given (act) to him (recipient). The children tended to produce phrases containing combinations of the patient, recipient, and act semantic elements represented in the examples above: David, Donald, Dennis, Chris, Kathy, and Tracy produced, respectively, 156, 64, 22, 23, 22, and 12 such phrases, representing 63, 76, 80, 79, 66, and 50 percent of the action phrases each child produced. Phrases containing the agent or actor element were produced less frequently than phrases with the other three semantic elements, and phrases with place of action and instrument elements were rarely produced.

Some of the children tended to produce their signs for the patient, recipient, and act semantic elements in consistent positions of their two-sign phrases. Specifically, as exemplified above, the children tended to produce phrases with patient-act, patient-recipient, and act-recipient orders (Fig. 1) (*9*). Not all children showed ordering tendencies for all pairs of the three elements; but if the children showed any ordering tendencies at all, those tendencies were ordered in

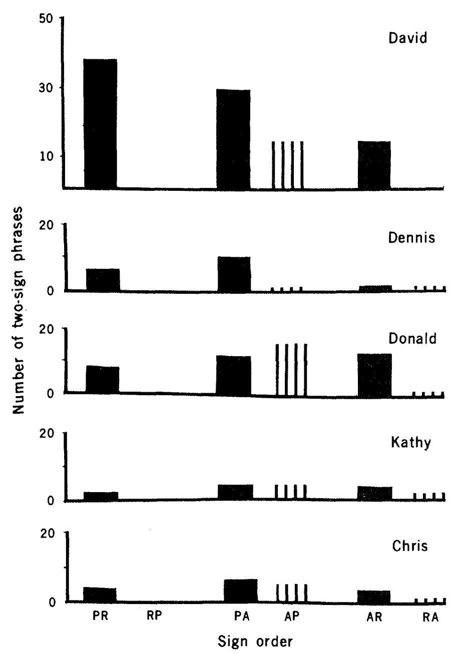

Fig. 1. Number of two-sign phrases classifed according to the order of each element in the phrase. Abbreviations: *P*, patient, the object or person acted upon; *A*, act, the action carried out to effect a change of either state or location; and *R*, recipient, the locus or person toward which someone or something moves. Patient signs tended to precede recipient signs (χ^2=36, P<.001 for David; by the binomial test, P<.03 for Dennis, P<.02 for Donald). Patients tended to precede acts (χ^2=5.48, P<.02 for David; χ^2=7.36, P<.01 for Dennis). Acts tended to precede recipients (χ^2=13.00, P<.001 for David; χ^2=10.28, P<.001 for Donald). Subjects were observed over varying periods of time: David was seen from 2 years 10 months to 3 years 10 months for eight sessions; Dennis from 2 years 2 months to 2 years 6 months for four sessions; Donald from 2 years 5 months to 4 years 6½ months for 11 sessions; Kathy from 1 year 5 months to 2 years 8 months for nine sessions; and Chris from 3 years 2 months to 3 years 6 months for three sessions.

the same direction. We can describe the children's two-sign phrases with the following element-ordering rule (*10*):

Rule A:

(choose any two maintaining order)

Phrase → (patient) (act) (recipient)

Thus, it appears that some of the children expressed semantic relations in a systematic way, that is, by following a syntactic rule based on the semantic role of each of the sign units.

The children also produced longer phrases that expressed at least two semantic relations. David, Donald, Dennis, Chris, Kathy, and Tracy each produced, respectively, 240, 12, 4, 8, 11, and 10 multirelation phrases, representing 31, 7, 10, 14, 17, and 12 percent of each child's semantic relation phrases. For example, David pointed at a picture of a shovel, pointed downstairs where a shovel was stored, produced a digging motion in the air with two fists, and finally pointed downstairs a second time. David had commented in one phrase on two aspects of the shovel, the act usually performed on the shovel and the habitual location of the shovel.

The child inventor. A crucial question is whether the deaf children rather than their caretakers first elaborated these signed communications. We observed that the children's mothers did use some gestures. To determine who invented the system, we transcribed the gestures produced by the mothers of two of our subjects during the first four interviews. Our impression was that these mothers did not alter their behavior in front of the camera and that our samples were representative of the mothers' communication efforts.

A comparison of the mothers' and the children's signs suggests that indeed it was the children who first produced the system. The children showed that they could invent characterizing signs by creating motor-iconic gestures for new stimulus toys they had not previously encountered. Although the mothers produced as many different types of characterizing signs as did their children, only about 25 percent of these signs were common to both mother and child (Table 1, column 1). There is thus some suggestion that the mothers' lexical vocabularies differed from their children's and that each of the children could invent characterizing signs on his own.

Furthermore, the children produced multisign phrases that conveyed semantic relations earlier than their mothers. Both children produced a number of these phrases in session 1. David's mother produced only three such phrases in

session 1 (compared to David's 27 during session 1), and Dennis' mother did not start production at all until session 2. In addition, the children produced many more multisign phrases conveying semantic relations than did their mothers. Over the course of the four interviews, David and Dennis produced 127 and 42 such phrases, respectively, while their mothers produced only 41 and 13, respectively. There is thus no evidence that the children learned to concatenate signs to express semantic relations by imitating their mothers' gestures.

Finally, the children were far more likely than were their mothers to use characterizing signs in their multisign phrases. The mothers produced as many characterizing signs in single-unit phrases as their children but far fewer characterizing signs in multisign phrases (Table 1, columns 2 and 3). Consequently, there is no indication that the children learned to integrate their characterizing signs into an ordered system by imitating their mothers' productions (*11*).

We have shown that a child can develop a structured communication system in a manual mode without the benefit of an explicit, conventional language model. This achievement is cast into bold relief by comparison with the meager linguistic achievements of chimpanzees. While chimpanzees seem to learn from manual language training (*12*), they have never been shown to spontaneously develop a language-like communication system without such training—even when that chimp is lovingly raised at a human mother's knee (*13*). On the other hand, even under difficult circumstances, the human child reveals a natural inclination to develop a structured communication system.

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References and Notes

1. Deaf children who are orally trained are instructed in lipreading and in speech production with no audio feedback. These children have been observed to spontaneously gesture to one another "behind the teacher's back." [L. Fant, *Ameslan* (National Association of the Deaf, Silver Spring, Md., 1972); B. T. Tervoort, *Am. Ann. Deaf* **106**, 436 (1961)].
2. A rationale and justification of our coding methods and a more detailed discussion of results are given by H. Feldman, S. Goldin-Meadow, and L. Gleitman [*Action, Gesture, and Symbol*, A. Lock, Ed. (Academic Press, New York; in press)].
3. Communicative signs were motor behaviors, directed to a person, which served no direct function in the setting. The physical form of the signs was described by a system similar to the one used to describe American Sign Lanuage. The dimensions used in the descriptions are described by W. C. Stokoe, Jr. [*Stud. Linguist. Occas. Pap. 8* (1960)].
4. A detailed account of the criteria for single signs and an account of the lexical data are given by H. Feldman [thesis, University of Pennsylvania (1975)]; the criteria for sign phrases and for the data on syntactic and semantic relations are described by S. Goldin-Meadow (*Stud. Neurolinguist*, in press).
5. A description of the method of rich interpretation is given by L. Bloom [*Language Development* (MIT Press, Cambridge, Mass., 1970); *One Word at a Time* (Mouton, The Hague,1973)].
6. The system we use to describe the deaf child's phrases is an adaptation of the case system presented by C. J. Fillmore [in *Universals in Linguistic Theory*, E. Bach and R. T. Harms, Eds. (Holt, Rinehart & Winston, New York, 1968), pp. 1–88].
7. R. Brown, *A First Language* (Harvard Univ. Press, Cambridge, Mass., 1973); D. I. Slobin, in *Studies of Child Language Development*, C. A. Ferguson and D. I. Slobin, Eds. (Holt, Rinehart & Winston, New York (1973), pp. 175–208.
8. The children produced a third type of sign, the marker, which did not refer to things and events but rather served modulation functions. Sign markers were head nods and side-to-side head shakes and were reminiscent of words such as "yes" and "no" in English; for instance, in the sentence "There are no trucks," the "no" modulates, in particular negates, the existence of trucks.
9. The data in Fig. 1 include only two-sign phrases. We exclude phrases containing three elements (such as point at book, "give" sign, point at self, to request that the book be given to the child) and also exclude phrases containing either repeated elements or simultaneously sign elements (such as point at book, "give," point at book; or point at book signed simultaneously with "give"). In addition, we exclude all phrases containing points at pictures because the children tended to point at pictures before producing other signs. The pictures pointed at were often facsimiles of objects playing the patient role; thus, we would have, perhaps artifactually, inflated our patient-first orderings if we had included these phrases. As a result, Tracy (observed for two sessions at 4 years 1 month and 4 years 3 months) was not included in this analysis because she produced very few action phrases which did not contain points at pictures. The data that appear in Fig. 1 represent 64, 83, 92, 70, and 86 percent of all the two-sign, pictureless action phrases produced by David, Dennis, Donald, Kathy, and Chris, respectively.
10. The following conventions are used in describing the order rule: (i)→ indicates that the symbol on the left can be rewritten as the symbol or symbols on the right. The order of the symbols on the right must be maintained in the rewriting process. (ii) ( ) indicates that the symbol in the parentheses is optional, that is, it either can or cannot be chosen in the rewriting process.
11. S. Goldin-Meadow and H. Feldman [*Sign Lang. Stud.* **8**, 225 (1975)].
12. R. A. Gardner and B. T. Gardner, *Science* **165**, 664 (1969); B. T. Gardner and R. A. Gardner, *Behav. Non-Hum. Primates* **4**, 117 (1971); A. J. Premack and D. Premack, *Sci. Am.* **227**, 92 (October 1972). Gardner and Gardner report that Washoe has invented signs for certain objects; although striking, this accomplishment does not address the issue of whether or not Washoe would invent such signs if she had not been exposed to a standard manual language model.
13. C. Hayes, *The Ape in Our House* (Harper, New York, 1951); W. N. Kellogg, *Science* **162**, 423 (1968). Although the Kellogg chimpanzee Gua occasionally did gesture (such as protruding lips toward a cup to mean "drink"), her gestures appeared to be far less explicit than our deaf children's signs (such as tilting a C-shaped palm toward the mouth several times without the cup in the hand, which was David's signs for "drink"); moreover, Gua did not combine signs into phrases as did our deaf children.
14. We thank D. Burke, J. Huttenlocher, K. Kaye, J. McClelland, and B. Meadow for reading earlier versions of this paper; E. Newport for helpful suggestions; L. Tefo and B. Gray for help in coding videotapes; our subjects and their families for continued cooperation throughout the study; and L. Gleitman for contributions to both our thoughts and language. Supported by a Spencer Foundation grant to S.G.-M. and H.F. while they were students at the University of Pennsylvania, an NSF graduate fellowship to H.F., an American Association of University Women predoctoral fellowship to S.G.-M., NIH training grant HD 00337 under the direction of J. Aronfreed, and NIH research grant HD 52744 to R. Gelman.

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Relative Fecundity and Parental Effort in Communally Nesting Anis, *Crotophaga sulcirostris*

Abstract. *The contribution of eggs to the communal clutch by females of the group and the genetic contribution by males of the group are significantly skewed. The amount of parental care performed by each bird is correlated with relative egg ownership for both sexes.*

True communal nesting, in which several females regularly deposit their eggs into a single nest, is now known to occur in a number of avian species such as rheas, tinamous, anis, ostriches, magpie geese, and pukekos (*1*). While the cooperative nature of this breeding system has been emphasized, the degree of skew in the clutch sizes of communal females has not been reported for any of these species. If the number of eggs the group can incubate or raise successfully is limited, females should attempt to ensure that the largest possible fraction of the communal clutch is theirs.

A phenomenon commonly observed in some of these species is the presence of eggs strewn about in the vicinity of the nest. Several explanations of this apparent wastage have been offered, usually in terms of negligence, poor breeding synchrony, improperly built or unfinished nests, the onset of male incubation, or predators (*1*). As part of a broader study of communal nesting in groove-billed anis (*Crotophaga sulcirostris*), I examined this question of egg loss and its implications. I report here that (i) egg losses are a direct result of competition among females, (ii) egg losses create a skew in the egg contribution of each female to the communal clutch, and (iii) the amount of parental care is correlated with relative egg contribution for both males and females (*2*).

Nesting groups of groove-billed anis consist of from one to four monogamous pairs. Such breeding units are stable